

Getting Out of Orbit: Water Recycling Requirements and Technology Needs for Long Duration Missions Away from Earth

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Deep-space crewed missions will not have regular access to the Earth's resources or the ability to rapidly return to Earth if a system fails. As crewed missions extend farther from Earth for longer periods, habitation systems must become more self-sufficient and reliable for safe, healthy, and sustainable human exploration. For human missions to Mars, Environmental Control and Life Support Systems (ECLSS) must be able to operate for up to 1,100 days with minimal spares and consumables. These missions will require capabilities to more fully recycle atmospheric gases and wastewater to substantially reduce mission costs. Even with relatively austere requirements for use, water represents one of the largest consumables by mass. Systems must be available to extract and recycle water from all sources of waste. And given that there will be no opportunity to send samples back to Earth for analysis, analytical measurements will be limited to monitoring hardware brought on board the spacecraft. The Earth Reliant phase of NASA's exploration strategy includes leveraging the International Space Station (ISS) to demonstrate advanced capabilities for a robust and reliable ECLSS. The ISS Water Recovery System (WRS) includes a Urine Processor Assembly (UPA) for distillation and recovery of water from urine and a Water Processor Assembly (WPA) to process humidity condensate and urine distillate into potable water. Possible enhancements to more fully "close the water loop" include recovery of water from waste brines and solid wastes. A possible game changer is the recovery of water from local planetary resources through use of In Situ Resource Utilization (ISRU) technologies. As part of the development and demonstration sequence, NASA intends to utilize cis-Lunar space as a Proving Ground to verify systems for deep space habitation by conducting extended duration missions to validate our readiness for Mars.